Where energies of more than E_D are transferred by the photons, host ions in the structure are displaced. The absorption of these high energy photons therefore generates point defects in the structure.

The point defects in-diffuse into an active quantum well region of the structure through subsequent high temperature (~700 °C) annealing. By controlling the irradiation of the structure, a regulated concentration of point defects can be introduced into the active region, and the degree of quantum well intermixing can be controlled.

The degree of novelty and inventiveness in the present invention is furthermore amply illustrated by the fact that development of QWI is a highly worked field, and a survey of 81 reports published during the period 1996 to 2000 carried out by the applicants did not yield a single publication that describes or proposed a QWI process that generates defects in a compound semiconductor structure using high energy photons and subsequent annealing, thereby facilitating the fabrication of multiple bandgap regions in a single step process.

The Examiner has rejected claims 1 and 4 to 9 on the grounds of lack of novelty. The Examiner considers that Burnham anticipates the manufacturing method of the present invention. The method in Burnham, however, is different from the present invention in a number of important respects. The method in Burnham does not introduce defects; instead the whole semiconductor structure is heated to within a few tens of °C below the thermal disordering temperature. Quantum well intermixing is induced by scanning the structure with a laser beam, those areas exposed to the laser beam being raised above the critical thermal disordering temperature. The Burnham

method, therefore, is seen to require the whole structure to be raised to a high temperature, somewhere between 750 and 850°C (see column 4, line 58). No additional annealing step is required in the Burnham method because the whole structure has already been heated to this high temperature.

Claim 1 recites "…irradiating…to generate defects…" and "…annealing the structure…". Since these limitations are missing from Burnham, the rejection of claims 1 and 4-9 under 35 USC 102 should be withdrawn.

At item 4 of the detailed action the Examiner suggests that the xenon lamp 44 as shown in Figure 2 of Burnham is the source of radiation which introduces defects. This cannot be so since no defects are introduced into the quantum well region.

At item 5, the Examiner proposes that the protective coating 62 as shown in Figure 3 of Burnham should be read as disclosing a mask for controlling the degree of radiation damage. The protective coating 62 is there to prevent out-diffusion of arsenic (As) (see column 5, lines 3 - 12). A radiation controlling mask is unnecessary because of the nature of the Burnham method. Items 6 through 9 are simply assertions that features of the claims are present in Burnham.

In the light of the preceding comments regarding claims 2, and 4-9, it is believed that each of claims 6 through 9 are also separately novel.

In passing, it is noticed that in item 7 the Examiner has identified the thermally disordered region 60 as analogous to the mask. This is assumed to be a typographical error.

As regards claim rejections on the grounds of 35 U.S.C. 103, the present invention is not only novel over the Burnham document, but also represents a very significant inventive step away from the Burnham technique. It is noted that the Burnham technique provides quantum well intermixing in a way which, though it requires the full structure to be raised to a high temperature, does not require the introduction of point defects in the quantum well region. It is clear that a person having ordinary skill in the art and knowing of the teaching of Burnham would be highly unlikely to attempt to solve the problem in a new way as has been done in the present invention. The background to the Burnham case discusses only diffusion and implantation techniques on the one hand and laser beam annealing techniques on the other, the use of a source of photons to generate defects where the photons have an energy which is at least the displacement energy (E_D) is neither taught nor suggested.

The applicants contend that the combination of the teachings of Burnham and Thompson fails to teach a method according to claim 2. It is clear from a full reading of Thompson that the plasma (ECR) source is not a radiation source for the purposes of the Thompson document. It is rather a source of helium particles which provides the required helium particle flux for in situ epigrowth interference. Furthermore, it is unclear why a person of ordinary skill would wish to dispense with the laser annealing process of the Burnham technique and incorporate a defect layer growth technique in its place. However, when the Burnham and Thompson teachings are combined, the resulting hybrid would still not disclose a step of irradiating a compound semiconductor structure with a source of photons to generate defects, as claimed in claims 1 or 2 of the present application.

Thus the rejection of claims 2, 3 and 16 under 35 U.S.C. 103 on this combination of references should be withdrawn.

The ECR plasma source taught in Thompson is not a radiation source in the sense of present claims 1 or 2 (i.e. it is not a source of photons having an energy at least that of the displacement energy). The Examiner's objections at items 13 and 15 are therefore traversed.

The Examiner also rejects claims 10 through 15 on the grounds of lack of inventive step in view of a combination of the teaching of Burnham with that of Poole et al. and Feldman et al. The Poole disclosure relates to an ion implantation technique for introducing point defects. To achieve disordering in localized regions, the Poole application discloses a patterned silica mask. The silica mask is not a gray tone mask or for that matter a photo resist as claimed in claim 10. The mask used in Poole is of a single predetermined thickness and therefore requires repeated application of different thicknesses of mask introduced locally on the wafer. As explained above it appears highly unlikely that a person of ordinary skill in the art would take the teaching of Burnham, combine it with the quite different ion implantation technique of Poole, and, without the exercise of inventiveness, arrive at a third technique: radiation-induced generation of defects within the quantum well region. As was emphasized above, it should also be noted that the dielectric-based selective ion-implantation induced disordering method described by Poole is only one of the many possible (different) ways to achieve selective quantum well intermixing that is currently being investigated.

The Feldman patent discloses the method of using gray scale mask to manufacture optical elements. Given the unlikelihood of a

combination of the teaching of Burnham and the teaching of Poole, the obviousness of a further incorporation of the teachings of the Feldman patent from a third field of technology is vanishingly small. The whole teaching of the Feldman patent is the fabrication of three-dimensional graded profiles on a photo resist, which is then subsequently transferred by etching onto the substrate to form the end result, a micro-optical element. Nowhere in the Feldman patent is there any teaching of the use of these patterned micro-optical elements as masks for controlling the degree of quantum well intermixing. This is not surprising given the distinct nature of the fields to which the Burnham, Poole and Feldman applications respectively relate.

Thus, the rejection of claims 10-15 under 35 U.S.C. 103 on this combination of references should be reversed.

The Examiner has correctly identified that the current application and the reference cited in the Examiner's report share a common inventor, namely OOI Boon Siew although the inventive entity is different. However it is noted that the method of quantum well intermixing claimed in US 2002/0072142 A1 is a variant on the ion implantation method, the variant being referred to as Thermally Assisted Implantation Vacancy Induced Diordering (TAIVID). There is no conflict between the claims of the present invention and those of the referenced document, since TAIVID explicitly requires the introduction of ions into a quantum well structure in order to induce defect formation. Additionally, the TAIVID method contrasts with the method claimed in the present application in that the TAIVID method does not teach or suggest using high energy photons to induce such point defects.

The TAIVID method introduces ions into the quantum well structure at an elevated temperature (said to be in the range from 200°C to a temperature near the characteristic crystal damage temperature for the quantum well crystal structure). This elevated temperature ion implantation is followed by a later annealing step, whereby quantum well intermixing is induced.

Since the present claim 1 defines a patentably distinct invention from that of claims 5, 33, 38, 39 and 41 of said application, the attempted double patenting rejection should be withdrawn.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

A check in the amount of $110.00 is enclosed for a one-month extension of time and additional claim fees. The Commissioner is hereby authorized to charge payment for any fees associated

with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

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